Multi-Scale Integration of Soft Polymers in Silicon Microsystems

In the past two decades, microelectromechanical systems (MEMS) technology has provided the means to reduce the size, weight, manufacturing cost, and power consumption of integrated sensors and actuators for modern military, space-craft, automotive, telecommunications, and biomedical applications. Because of the historical background of MEMS technology originating from integrated circuit (IC) processing technology, MEMS devices have been fabricated primarily through applying "top-down" photolithography methods to silicon materials. In recent years, new polymer-based micro/nanofabrication methods have actively been explored to meet increasing demands for rapidly and economically forming nanometer-sized structures for nanosciences research and nanotechnology applications. These emerging fabrication techniques include "bottom-up" self-assembly processing and soft printing of organic nanostructures. An important, unexplored MEMS research frontier exists for achieving the integration of these nanostructures into a microelectromechanical system across multiple dimensional scales ranging from a few nanometers to several micro/millimeters. This talk discusses our MEMS fabrication technique to integrate polymeric micro/nanostructures within micro/mesoscopic devices and systems in functionally scaled products through permitting hierarchical, continuous structuring across multiple scales. Our device process is achieved by soft molding and release of a three-dimensional (3-D) polymer microstructure with nanoscale features and grafting of the microstructure onto silicon MEMS device structures with high accuracy. The adoption of the micro/nano soft molding approach in the MEMS fabrication could permit transfer of a wide variety of nanoscale polymeric morphologies to a MEMS device surface. The unique optical and mechanical properties of the integrated polymer features promises to enable the construction of new mechanically reconfigurable, in other words, "stretchable" photonics devices, such as strain reconfigurable optical gratings, diffraction-based variable-focus lenses, and strain tunable photonic crystals.

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Dr. Kurabayashi received his Bachelor's degree in Precision Engineering at the University of Tokyo in 1992 and his M.S. and Ph.D. degrees in Materials Science and Engineering from Stanford University, in 1994 and 1998, respectively. Upon completion of his Ph.D. program, he was hired as a Physical Science Research Associate with the Mechanical Engineering Department at Stanford University and participated, for a year, in a DARPA funded project aiming to develop MEMS-based microfluidic technology for future IC cooling. In January 2000, he joined the University of Michigan, Ann Arbor, where he is currently an Associate Professor of Mechanical Engineering and Electrical Engineering and Computer Science. His group at Michigan studies RF MEMS reliability physics, biomolecular motor hybrid NEMS/MEMS technology, polymer-on-silicon MEMS photonics, micro gas chromatography (mGC), protein/cell patterning for bioelectronics and biosensors, funded by NSF, NIH, NASA, CIA, DARPA, and industries. He authored and co-authored more than 100 journal and conference papers. He is a recipient of the 2001 National Science Foundation (NSF) Early Faculty Career Development (CAREER) Award, the University of Michigan Robert Caddell Memorial Award (2004), and Pi Tau Sigma Outstanding Professor Award (2007).

